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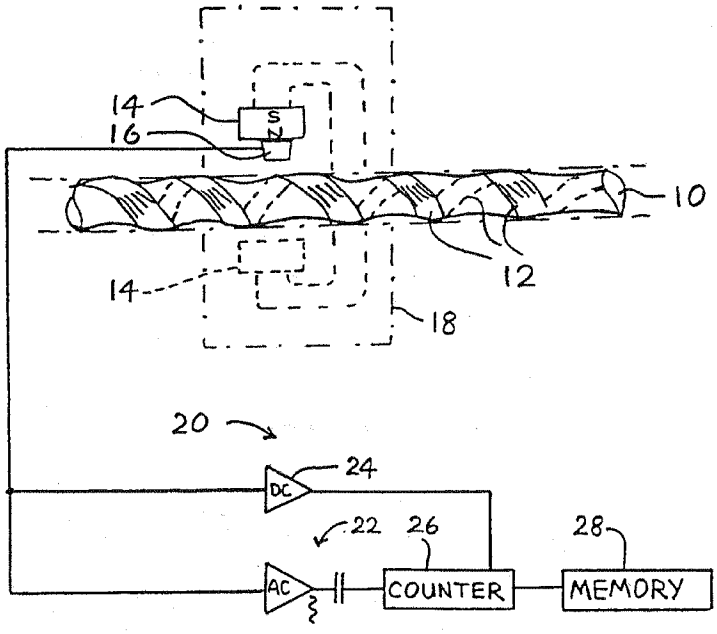
(54) Measureing displacement of elongate elements, particularly wire ropes

(57) A wire rope 10 is an example of an element whose ferromagnetic properties vary periodically along its length, owing to its coiled construction. If displaced through a magnetic field (produced by a magnet 14), the magnetic reluctance adjacent it is varied periodically. A small detector (suitably a Hall effect device 16) located close to the rope 10 provides a correspondingly varying electrical signal which can be processed to provide a series of pulses that can be stored and used to provide a display related to the displacement rate. Two detectors may be spaced apart along the length of the rope in order to obtain an indication of the displacement direction.



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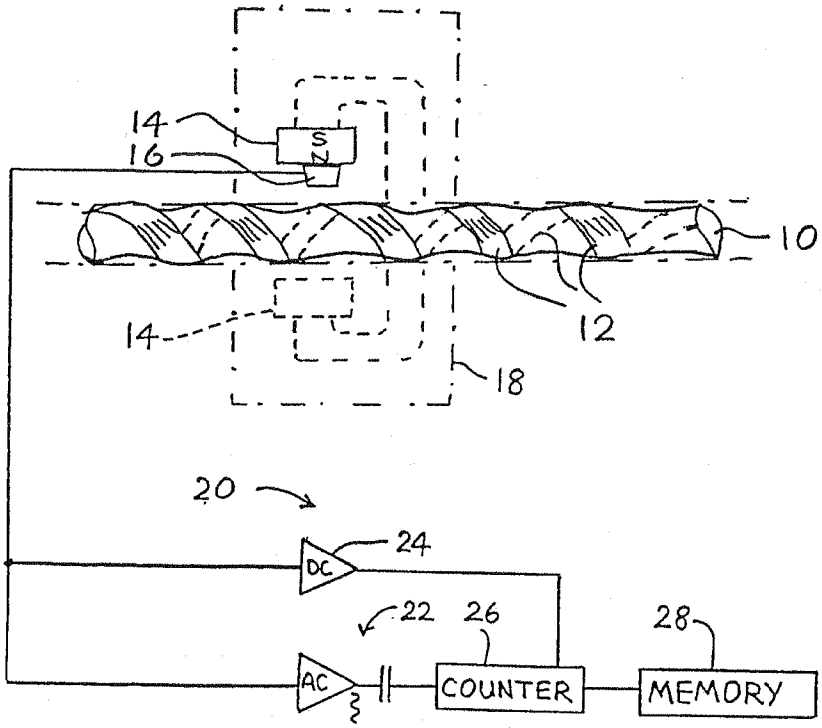

SPECIFICATION

Measuring displacement of elongate elements particularly wire ropes

The present invention relates to measuring the displacement of an elongate element, particularly of wire rope.

Conventional methods of measuring the linear travel of a rope depend on frictional contact. Thus the rope may be urged to rotate a pulley, whose rotation is measured. This requires a bulky supporting and measuring station, often with a digital encoder. The whole is quite elaborate and expensive. It tends to be somewhat inaccurate and unreliable, being affected by ambient conditions, e.g. moisture which may cause slipping of the rope on the pulley.

Broadly, the present invention involves arranging for the displacement of an elongate element to produce a varying magnetic field, whose variation is detected to provide a signal related to the displacement. If the element has non-uniform magnetic properties, and its displacement is arranged to carry it through a magnetic field (which may be static and generally invariant) the field is disrupted in a manner dependent on the nature of the nonuniformity of the element and the rate of its displacement. If the non-uniformity has a regular period, it is simple to correlate the field variation with the rate of displacement.

A wire rope is composed of a multiplicity of strands twisted together. Surprisingly, the present inventor has found that when such a rope (of steel wire) is displaced (lengthwise) past a magnet, the field detected adjacent the rope varies regularly, with a period corresponding to the periodicity with which the strands were laid up in the manufacture of the rope. This is because the field at a point is sensitive to the reluctance in its immediate neighbourhood. Although the cross-sectional area of the rope is substantially constant along its length, a line drawn parallel to its axis is tangent at peaks which are separated by air gaps. For a sensor adjacent the rope (and located generally between the rope and the magnet), the flux is detectably higher when it is adjacent a peak (i.e. when a strand is passing) than when it is adjacent a gap. Thus the sensor (e.g. a Hall device) can provide an output that varies in accordance with the displacement of the rope. Experiments have shown that ordinary steel ropes are wound with sufficient consistency of lay up for the sensor's output to be analysable to provide displacement information with a resolution of one turn of the lay up (a dimension that is generally comparable with the diameter of the rope).

In one aspect the present invention provides a method for measuring displacement of an elongate element comprising providing means such that the displacement produces a varying magnetic field, the variation being related to the displacement; and detecting the variation to derive a signal related to the displacement.

In a second aspect the present invention provides apparatus for measuring the displacement of an elongate element comprising magnetic field means such that displacement of the elongate element can be caused to produce a varying magnetic field; and detector means arranged to sense such a varying magnetic field and provide an output related to the displacement. Suitably there are guide means for guiding a said elongate element along a path passing through the region of a field produced or produceable by the magnetic field means. There are preferably means for mounting the magnetic field means adjacent an intended pathway of the elongate element, with the detector means mounted between the magnetic field means and the intended pathway.

Thus apparatus according to the invention can comprise a magnet and a magnetic field sensor arranged to be mounted adjacent a wire rope (or other elongate element preferably comprising ferro-magnetic material). The sensor may be connected to signal processing means with a display indicative of the rope's displacement.

To provide an indication of the direction of travel of the rope, use may be made of a second sensor spaced a short distance away in the travel direction, possibly at 90° (about the rope). Use may then be made of a syncronous up/down counter. The pulses from the two devices caused by the helical lay-up of the rope will be separated by a time delay. Hence there are two outputs to compare. Moving one way, the potential of the output from one point will be higher than that from the other, giving a positive potential difference from the first sensor to the second. Movement in the other direction results in the reverse and leads to a negative potential difference. Such potential differences make the signals easy to analyse, suitably by means of pulse analysis in quadrature. Alternatively, if the magnet is offset from the axis of the Hall effect (or other) sensor, it can be arranged that the output of the sensor is in the form of AC pulses with a DC shift whose polarity is indicative of the travel direction. Thus direction indication can be provided using only a single sensor, but the analysis of the data may be more complicated than for the two sensor case.

In a further aspect the invention provides apparatus including a displaceable elongate element (e.g. a winding rope in a mine), and measuring apparatus according to the second aspect, suitably comprising a magnet and sensor mounted adjacent the element.

An embodiment of the invention will now be described in greater detail with reference

to the accompanying drawing which is a schematic view of apparatus embodying the invention.

The apparatus is shown in conjunction with a steel rope 10, composed of substantially helically coiled strands 12. In this example the diameter of each strand is one eighth that of the rope.

A polarising magnet 14 is mounted adjacent the rope 10. It may be a permanent magnet, thus minimising power consumption and complexity. Good results are obtained with a simple magnet at one side of the rope, though a pair of magnets (or two jaws of one magnet) may be located on opposite sides as indicated in broken lines. A Hall-effect sensor 16 is mounted adjacent (but out of contact with) the rope 10. In this example it is on the magnetic axis, and mounted to the magnet 14 in a sensor unit 18. The sensing portion of the sensor 16 is small in relation to the diameter of the strands 12.

The sensor 16 has an output terminal which is connected to signal processing circuitry 20 which converts a varying output voltage from the sensor 16 to a train of pulses (by amplifying, squaring and differentiating the signal using an AC amplifier and differentiator 22 and a DC amplifier 24.) The pulses are counted by a counter 26 and stored in a memory 28.

It will be appreciated that the system involves no moving parts in the detector, and detection is unaffected by dirt, moisture or oil on the rope. The components can be cheap and readily available. The circuitry can operate with a low voltage supply, with a very low power consumption.

It may be pointed out that rotation of the rope through one turn will lead to a count of one. Generally this will be an undesired error input, but of course the apparatus could be used to measure such rotation. Indeed, with more sophisticated processing circuitry (possibly using more than one sensor) it could measure both translation and rotation simultaneously.

CLAIMS

1. A method for measuring displacement of an elongate element comprising providing means such that the displacement produces a varying magnetic field, the variation being related to the displacement; and detecting the variation to derive a signal related to the displacement.

2. A method according to claim 1 wherein the elongate element has magnetic properties that vary in the displacement direction and a magnetic field is provided in a region through which it is displaced, so that the field adjacent the element in said region varies with the displacement to provide said detected variation.

3. A method according to claim 2 wherein the elongate element is a wire rope comprising coiled ferromagnetic strands arranged so that its magnetic properties vary periodically along its length.

4. A method for measuring displacement of an elongate element substantially as any herein described with reference to the accompanying drawing.

5. Apparatus for measuring the displacement of an elongate element comprising magnetic field means such that displacement of the elongate element can be caused to produce a varying magnetic field; and detector means arranged to sense such a varying magnetic field and provide an output signal related to the displacement.

6. Apparatus according to claim 5 wherein the detector means comprises a Hall effect sensor.

7. Apparatus according to claim 5 or 6 for measuring the displacement of an elongate element which has magnetic properties that vary in the displacement direction; wherein the magnetic field means comprises means for providing a magnetic field relative to which the element is displaceable along an intended pathway.

8. Apparatus according to claim 7 having guide means for guiding a said elongate element along a path passing through the region of a field produced or produceable by the magnetic field means.

9. Apparatus according to claim 7 or 8 having means for mounting the magnetic field means adjacent an intended pathway of the elongate element, with the detector means mounted between the magnetic field means and the intended pathway.

10. Apparatus according to claim 7,8 or 9 having means for mounting the magnetic field means adjacent an intended pathway of the elongate element with the magnetic field means offset relative to the axis of the detector means so that, in use, the output signal from the detector means has a DC shift whose polarity is indicative of the displacement direction; the apparatus including means for detecting the shift polarity and providing by means thereof an indication of the displacement direction.

11. Apparatus according to any of claims 5 to 9 wherein the detector means comprises two detector elements which in use are spaced apart in the displacement direction of the elongate element; and means for comparing their output signals to determine the direction of travel of the elongate element.

12. Apparatus according to any of claims 7 to 11 wherein the magnetic field means is a permanent magnet.

13. Apparatus for measuring the displacement of an elongate element substantially as any herein described with reference to the accompanying drawing.

14. Apparatus comprising a displaceable elongate element and apparatus for measuring its displacement according to any of claims 5

to 13.

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